# THE LOWER FORMS

OF

# LIFE FOUND WITHIN THE ORAL CAVITY.

BY

C. N. PEIRCE, D.D.S.,

PHILADELPHIA.

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IN the preparation of this essay I shall endeavor to give not only a description of the organism to which has been assigned a prominent influence in the production of dental caries, but also to embrace all of the lower forms of life which the microscope reveals within the oral cavity.

The first, and not an easy problem to be solved in the examination of these minute objects, is their true place in nature. Having decided that they are organic, the next query is, Do they belong to the flora or fauna—plant or animal? The casual observer notes a broad distinction. To him the old definition, "that an animal is possessed of life and locomotion, and a plant of life without locomotion," seems to be sufficient, until, some day, traveling beyond the circuit of his dirunal route, he meets with animals without locomotion (zoophytes), and plants with locomotion (diatomaceæ).

Such an encounter confuses the novice, and his resolve to further investigate only adds to his bewilderment, for similar instances multiply until the evidence produced is so strong that he is compelled to desert his position and seek refuge in the declaration that "one kingdom runs into the other so imperceptibly that no line of demarkation can be drawn between them." Nor does this

similarity cease with the external characteristics; so close is the mutual relationship existing between all the vital forces, that they may be legitimately regarded as modes of one and the same force; this so-called vital force being evolved within the living bodies of plants and lower animals by the transformation of heat, light, and chemical action obtained from without. Dr. Carpenter states that the "vital force which causes the primordial cell of the germ first to multiply itself, and then to develop itself into a complex and extensive organism, was not either originally locked up in that single cell, nor was it latent in the materials which are progressively assimilated by itself and its descendants; but it is directly and immediately supplied by the heat which is constantly operating upon it, and which is transformed into vital force by its passage through the organized fabric which manifests it." In plants, and in lower tribes of animals, we are able to trace a most undoubted relationship between the vital activity of each individual and the amount of heat which it receives from external sources.

There is, then, good reason for regarding *temperature* as exerting a most important influence in favoring not merely increase in size, but specialization of development. That the rate of growth in plants depends largely upon the amount of light and heat to which they are subject is a familiar fact. By variations in temperature the rapidity of movement of the particles in the cell may be seen to be increased or diminished at pleasure. The amœboid activity of a white blood-corpuscle is similarly stimulated by the influence of heat. We know also that the hatching of eggs and the germination of seeds are likewise hastened or retarded according to the degree of heat to which they are subjected.

Two fundamentally opposite doctrines have been maintained as to the nature of life. Under one or the other of these all the various views promulgated on this subject may be ranged. According to the one school, life is to be regarded as the principle or cause of organization; and according to the other, life is the product or effect of organization.

By many physiologists, *vital* actions have been supposed to be altogether special in kind, to be the peculiar manifestations of the inherent activity of the organized body, and to have no necessary relationship with the physical forces of the inorganic world. Lately this view has undergone an important modification. "*Vital*

phenomena, instead of being looked upon as altogether peculiar, were gradually more and more recognized as the result of physical forces which had been transformed or conditioned in various ways by their passage through the organism." And now among many advanced physiologists the same kind of correlation is implicitly believed to exist between the *vital* and the *physical* forces, and between the several vital forces, as we know exists between the physical forces among themselves.

Some there are, however, who still contend that there is such a thing as a peculiar "vital force"; a something which finds no place in this circle of correlated energies. Dr. Lionel S. Beale, for instance, says in his new work on "Protoplasm": "In order to account for the facts, I conceive that some directing agency of a kind *peculiar to the living world* exists in association with every particle of living matter, which, in some hitherto unexplained manner, affects temporarily its elements, and determines the precise changes which are to take place when the living matter again comes under the influence of certain external conditions."

Various efforts have been made to define life. Bastian gives it as "an abstract name for those sets of attributes or force-manifestations of living beings which are usually spoken of as vital phenomena." M. Dumas says: "There is an eternal round in which death is quickened and life appears, but in which matter merely changes its place and form." Bichat was led to define life as the "functions together which resist death." Herbert Spencer defines it as "the continuous adjustment of internal relations to external relations." This is probably the most appropriate statement which can be given concerning the phenomena presented by living things; and the test of this appropriateness must be made by judging just how far it is applicable as an explanation of the phenomena exhibited by the lowest forms of life.

As it is not the purpose of this paper to advance any special theory respecting the origin of life, I leave it with these few suggestions, to be carried to more ultimate results by individual minds. All fermentations have until quite recently been supposed to be the result of spontaneous decomposition of organic matter within a fermentable liquid. It was said that in coming in contact with air, this organic matter undergoes a special change, which gives it the character of leaven, and this was regarded as an agent having

the power of spreading the decomposing movement. It is true, brewer's yeast had long been well known; the fact of its cellular composition and its organization were familiar; but no relation was recognized between this organized condition and those phenomena of fermentation produced by yeast in saccharine liquids, such as grape-juice or the wort of ale. It was always denied that anything else could be observed in alcoholic fermentation than an operation resembling all those slow decompositions that were classed among fermentations. Alcoholic fermentation, instead of being an exception, is, on the contrary, the very type of the phenomena of which I propose to treat; yeast-cells, far from being unimportant, take an essential part in it, and in all fermentations whatever there occur low organizations, microscopic corpuscles more or less analogous to those of yeast. At least this is the result of investigations carried on during the last fifteen years by several men of science, prominent among whom are Robin, Küchenmeister, Pasteur, Bastian, Papillon, and others, to whose investigations and records I am largely indebted for whatever of value may be found in this paper. The experiments of M. Pasteur and M. Dumas have proved beyond a doubt that in the case of any saccharine liquid exposed to the air, the more or less rapid production of alcohol is always connected with the production of a microscopic plant, consisting of rounded globules, a few thousandths of a millimetre in diameter. "These globules multiply in the fermenting liquid at the expense of the organic matter it contains, and in this way they produce decomposition of the sugar into alcohol and carbonic, succinic, and glyceric acids. These are the four invariable products of alcoholic fermentation. Sugar is the food of the yeast-plant; these products are its excretions." We have seen that the fermentation of sugar yields alcohol. The alcohol, brought in contact with certain substances, can absorb the oxygen of the air and transform itself, by oxidation, into acetic acid. A phenomenon of this kind occurs in wine when it sours, the alcohol contained in it being changed into acetic acid; only the agent in the transformation is in this case a microscopic plant, made up of little elongated globules, some thousandths of millimetre in diameter, these microscopic cells being the vehicles of the oxygen.

When milk turns sour that phenomenon is also due to the formation of lactic acid. This proceeds from the decomposition of

sugar contained in the milk, the microscopic beings accompanying this change assuming the form of the yeast-plant.

All of these fermentations, and many others similar in kind, participate in the *nutrition* and *development* of microscopic beings, presenting various forms, and known as *vibrios*, *bacteria*, *torula*, *leptomitus*, *leptothrix*, etc. These facts, then, having been established, we must consider that all ferments, as well as the degeneration and decay of vegetable and animal tissue, offer not only a habitat, but greatly stimulate the fecundation and development of myriads of infinitely little *threads*, *filaments*, and *corpuscles*, all cryptogamic plants, and belonging exclusively to the *fungi* and *algæ*.

Now, whence come these organized microscopic plants, which we see are almost inseparable from the alterations of organic matter? Upon this great problem adverse opinions are advanced with warmth, and maintained with experiments and profound reasoning. Yet, with all the light thrown upon it, some believe that these little bodies grow by spontaneous generation; while others assert, and profess to have proved, that they come from germs floating in the air, and universally disseminated throughout the body by the medium of the circulating fluid. Whichever theory be correct, one fact is certain: these embryonic germs of microscopic beings play an important part in the organized world—persistent followers of decay, ever-present revelers in disease, lying always in wait to pierce the internal machinery of animals and plants, playing high carnival at the disorganization of tissue in disturbances serious or unimportant.

"Life resists or escapes them, but nothing can contest with them its deserted vesture. The corpse is their natural aliment, and death their chosen laboratory. There these lowest of created things work out their lofty destiny in the eternal drama of renewal of organic existences."

We, as dentists, are more particularly interested in those forms found in the oral cavity of man, and that we may appreciate their influence we need to be familiar with their morphology, the soil which affords them nourishment, and the gaseous medium which surrounds them. No plant can thrive on merely mineral soil, but requires also organic substances; if, therefore, these organisms in the mouth are to develop and multiply, it must be either at the

expense of the animal tissues and the surrounding secretions, or of foreign substances taken into the mouth. The great law of *selection* must also be obeyed wherever these organisms are to prosper. "The choice of the locality depends upon the peculiar properties of the soil sought for or avoided by the various species of plants." For certain species seem to thrive best in certain localities. The nature of the gaseous medium in which those in the mouth seem to develop and multiply, is rich in carbonic acid, as is the case with all of the algæ accompanying the process of fermentation.

Accumulations of food around and between the teeth, degeneration and disintegration of tissue from improper nutrition or other causes, as well as want of cleanliness generally, all favor the growth of these organisms. Their development is usually very rapid; the function of reproduction is also very intense. A knowledge of these circumstances enables us to form some general theory for the treatment and control of these low organisms. It is not infrequently that epidemic diseases have been attributed to certain microscopic vegetable parasites; but that this idea has not been generally received, the following criticism from Robin will attest. He says: "This whole hypothesis is merely an attempt of medical men to seek the external conditions of the existence of universal affections in the changes of the internal constitution of beings, their atoms and molecules. Should there really be such vegetable parasites discovered in epidemic diseases, they might rather pass for consequences of the epidemic disorders than for the causes of such epidemics."

These restrictions apply with equal force to the organisms in the oral cavity, found as they are wherever there is a vitiated condition of the secretions or a destruction of the tissues, whether it be that of tooth-structure, ulceration of the soft tissues, or degeneration of particles of food,—and it is a question worthy of consideration whether the presence of these organisms might not rather pass for consequences of the disorder than causes. So much for the theory of their origin and development.

I come now to the more practical part of the investigation, and shall endeavor to be as brief as possible in giving an accurate sketch of each variety of organism as it is found in the oral cavity; and in collecting this information I am much indebted to Dr. Frederick Küchenmeister's work on "Animal and Vegetable Parasites of the Human Body."

The following are the varieties, and the order in which they shall be described :

1. Oidium albicans.
2. Cryptococcus cerevisiæ.
3. Leptothrix buccalis.
4. Leptomitus.
5. Bacteria, vibrios, and monads.
6. Paramecia.
7. Heterogeneous mass.

The first I shall notice is that found in what is called "infantile sore mouth," or thrush. This affection, though occurring at all ages, is much more common in early infancy, and upon this ulcerated surface, with the aid of the microscope, is found a growth which has been termed

*Fig. 1.* OIDIUM ALBICANS, OR WHITE PLANT.

As revealed to the observer, it seems to consist of thickened epithelial cells, mingled with numerous minute sporules or seeds, from the midst of which long, thread-like, jointed and branching plants arise, mycelium, intertwining with each other.

The question as to whether this vegetable growth is the origin or sequence of the disease has not yet been settled. Prof. George B. Wood states, in his treatise on the "Practice of Medicine," that "those who believe it to be the cause of the disease, suppose that its sporules, floating in the respired air, attach themselves to the mucous surface, and under favorable circumstances become developed and propagate. These circumstances may consist in some previous morbid state, changing the buccal secretion from its normal alkaline character to that of acidity, which probably favors the growth of this as of other microscopic fungi." Admitting this to be correct, it does

FIG. I.

not prove this organic development to be the cause of the disease, or contagious in its character, for, so far as I can learn of its prevalence or predisposition, it occurs most frequently in the mouths of persons living in situations where the air is impure and diet unwholesome, or where previous gastric or intestinal disorder has interfered with the health and vigor of the infant. If in the aged, it is where advancing years have promoted the degeneration of itssue and increased the pabulum whereon such growth may prosper.

So it will be safe to estimate it only as a symptom of disease, a natural sequence of a condition, and not a primary cause. This disease manifests itself sometimes in the form of small points, rings, conical and semi-spherical elevations, and also in the shape of large spots. The external portion or surface possesses a more or less soft cheese-like consistency, and is more or less thick; it adheres more firmly at first than at a later progressive stage, and finally peels off without injuring the continuity of the mucous membrane. It is found alone or simultaneously on the inner edge of the lips, where the mucous membrane begins. on the inner side of the cheek, on the gums and palate, on the upper and lower surface of the tongue, in the throat, and in the œsophagus, down as far as the cardia, or upper opening of the stomach.

*Fig. 2.* CRYPTOCOCCUS CEREVISIÆ—*Cell or Capsule.*

This plant is composed of round or oval cells, which present in their interior one or two little corpuscles, resembling somewhat an oil-globule. They are propagated with great rapidity when in

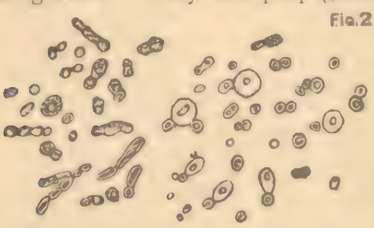


FIG. 2

contact with decomposing substances at a favorable temperature. Their development is by small projecting bodies on the sides of the cells, which, when they attain the size of the parent, originate new germs, and in this way form a row of from three to six elongated cells, never, however, becoming confluent, so as to form a a cylindrical rod or stem. This cryptococcus is so similar to that found in yeast, beer, ale, and sour milk, that it may be considered practically identical, the principal difference noticed being a

variation in the size, while in shape, manner of propagation, and apparent globule within, the modifications are but slight. It is developed in the morbid secretions of the mouth, the œsophagus, and stomach; it is also introduced into these situations by the drinking of beer. On examining the secretions of the mouth when first rising in the morning, it is readily detected in the mucus, saliva, and remnants of food.

In the black fur of the tongue of persons laboring under typhus, or in the oral secretions where persons have been long sufferers from organic disease, it is also found. Küchenmeister speaks of it as being the so-called "cholera fungi" of Swayne, Brittan, and Budd, which they found in the vomited matter of cholera patients. Vogel thinks it of great importance to regard this plant only as an accompaniment and not as the cause of disease—a result of the altered conditions of the fluids, which have assisted its development, but never the cause of this change.

*Fig. 3.* LEPTOTHRIX BUCCALIS—*Slender hairs in the month.*

This consists of delicate structureless fibres, of various lengths, and straight or curved, as the fibre is long or short. One end is free, the other is planted in or projecting from a fine granular mass, though a limited number are always noticed floating in the secretions, detached from any substance. They are found single or in bundles, and multiply with great rapidity. Scarcely any portion of the mouth is free from them. They appear on the surface of the tongue, in depressions of the teeth, and cavities of decay, on the necks and surfaces of the teeth; indeed, everywhere within the oral cavity that lodgment can be found for a particle of food. The multiplicity of appearances they present would almost lead one to suspect they were of different varieties. You scrape the surface of the tongue when it is slightly furred, and you have presented a mass of epithelium scales, many

FIG 3

Fig. 3. Leptothrix Buccalis, growing from epithelium scales.

of which have projecting from their surface straight rods, like bristles from a brush, or teeth from the centre of a fine-toothed comb. The same appearance is presented when particles are taken from cavities of decay or interstices of the teeth, but when removed from inflamed or ulcerated surfaces of the mucous membrane, or tongue, or debris from the necks of the teeth, the fibres are long, wavy, and curved, sometimes resembling a mass of exquisitely fine hair twisted into cylindrical form, and then spreading out into diverging rays, separating into two or three distinct masses like branches from the trunk of a tree. Again, they intertwine like meshes of a net, crossing each other in every direction, thus modified by locality, environment, etc., presenting dissimilar appearances. In watching for a length of time the free ends of these fibres, a slight vibrating motion is not only discernible, but from these ends small portions are constantly being detached, which resemble the bacteria and vibrios surrounding them, and by many are believed to be the same.

FIG. 4.

Fig. 4. Leptothrix Buccalis, growing from tartar.

FIG. 5

Fig. 5. Leptothrix Buccalis, growing from inflamed mucous membrane.

These fibres of leptothrix, as has been remarked, are found in cavities of decay, and not less abundantly where nature has been successful in arresting the progress of caries than in those where decay is rapidly progressing, provided decomposing portions of food are there. They are found also growing from the surface of accumulations of tartar, whether such accretions be upon the necks of the teeth, in the cavities of decay, or or on artificial dentures. There is probably no situation where

they grow with greater rapidity than on the surfaces of the plate, either upper or under. The soft, cheese-like substance that so quickly accumulates there is most prolific in their production, though from this situation they are neither so long nor attenuated as those taken from an inflamed mucous membrane. While great care in cleanliness limits their number, it is impossible to entirely eradicate them or prevent their development.

Any mouth, however free from accumulations of food, would still furnish sufficient aliment for their development and multiplication, from the natural waste of the tissues. *For no sooner does highly-organized tissue wane in its vitality, than its constituent particles, individualizing themselves, give rise to lower forms of life.* Let me not be understood as speaking of leptothrix as growing exclusively in the mouth, for such is not the case. It is very readily developed in infusions of animal and vegetable tissue when kept at a favorable temperature.

Fig.6

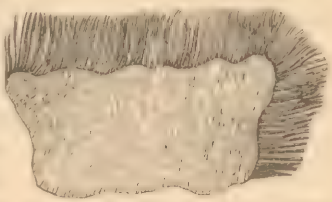


Fig. 6. Leptothrix Buccalis, growing from softened dentine.

### *Fig. 7.* LEPTOMITUS—*Slender Threads.*

This growth, as the name indicates, is neither so long nor so slender as the leptothrix. It also has occasional branches, and marked transverse striæ, which complete its morphological difference from the plant just described. It is found upon the tongue and in the pharynx of persons suffering from pneumonia, pleuresia, phthisis, apoplexia, and chronic gastritis. While it is not so frequently found as leptothrix, there being many situations and conditions favoring the development of the latter where leptomitus does not appear, yet wherever leptomitus is, there we are quite sure to find leptothrix.

Fig.7

Of this plant there are several varieties, varying, however, not so much in appearance as in locality or habitat, and recognized as *leptomitus oculi*, *leptomitus uteri*, *leptomitus epidermidis*, etc.

## Bacteria and Vibrios.

These organisms form some of the most minute objects which the microscopist has the opportunity of examining, and it is with the greatest difficulty their structure can be accurately determined. These two varieties we have placed together because they are invariably found in the same solution or infusion, and are developed under similar conditions; their number, size, and the rapidity with which they multiply depending entirely upon the amount of degenerating vegetable and animal tissue, and the temperature in which it is kept. They are both found in the fluids of the mouth, but the profusion in in which they exist is modified by the care exercised in keeping the fluids of the oral cavity free from decomposing substances. In the fangs of teeth where the pulps are devitalized they are found to rapidly develop. Nor is their presence in this locality confined to such teeth as have defective crowns giving communication with the fluids of the mouth, but in a number that were examined where there was devitalization of the pulp without any loss of the hard tisssues from caries or otherwise, their presence was readily detected. Upon opening into such cavities, they were, as usual, very offensive from the degenerated pulp, and on examining this putrid material these living organisms were observed in abundance. Their presence in these cavities, secluded as they were from any contact with the atmosphere or secretions of the mouth, must be accounted for in one of two ways, viz., the embryonic germs of these organisms must have been carried there through the circulating medium, so that the moment death

Fig.8.

Fig. 8. Leptothrix, Bacteria and Vibriones found in vegetable infusions.

Fig.9

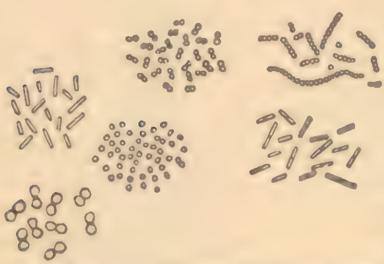


Fig. 9. Bacteria and Vibriones in different stages of development.

and degeneration of this higher tissue took place there they developed and multiplied; or else it must be that when the vitality of this vascular tissue is on the wane, its constituent particles are capable, by individualizing themselves, of growing into the low organisms in question.

## MONADS.

With these two low forms of life we must associate what are known as *monads*, or, as Bastian calls them, *plastide-particles*. These are invariably found in the same solutions with the former, and are supposed by some observers to result either by direct growth and development, or by aggregation and coalescence, into bacteria and vibrios. This latter view was advanced by both Dr. Hughes Bennett and M. Dumas, the former stating that he has actually seen the union above mentioned taking place. Whatever may have been the theories advanced respecting the origin and nature of bacteria, there is yet no clear, settled conviction in regard to them.

"Naturalists have been in doubt as to whether they should be regarded as independent living things of the lowest grade, having an individuality of their own, or whether, rather, they should be looked upon as developmental forms of some higher organisms, either animal or vegetable." The four principal views concerning them are as follows: 1. Ehrenberg contends that they are *animal organisms* of the lowest grade, having an individuality of their own. 2. Haller thinks they are of the nature of spores, produced from and destined again to develop into some of the simplest microscopic fungi. 3. Cohen thinks they represent a free-swimming stage in the existence of certain algæ. 4. It is asserted that they are the first and most common developmental phase of newly-evolved specks of living matter, which are capable, either singly or in combination, of developing into many different kinds of living things. This fourth and last view has been advanced by Bastian, he believing that they are largely the result of the direct growth and development of what he terms plastide-particles or monads. The bacteria are, as most commonly seen, both straight and curved rod-like bodies, varying in length from $\frac{1}{15000}$ to $\frac{1}{2000}$ of an inch, with a joint or line dividing them into two equal parts. Their movements vary both in rapidity and manner, sometimes

oscillating, at others of an irregularly rotating character. They are supposed by many to develop into the leptothrix, which we have found so persistent in the oral cavity. However this may be, any careful observer will recognize their similarity to the short rods which are constantly being detached from the free ends of the leptothrix as they grow in such profusion in the mouth. Cohen (in the *Quarterly Microscopical Journal*, 1873, p. 163) recognizes the surprising resemblance of the microspores of an interesting oscillarian alga crenothrix to bacteria, although he thinks there is no genetic connection between the two. He defines the bacteria as "chlorophyl free cells of spherical, oblong, or cylindrical form, sometimes twisted or bent, which multiply themselves exclusively by transverse division, and occur either isolated or in cell families."

"They make fluids milky unless they have nearly the same refractive index." Their diameter is not more than $\frac{1}{20000}$ of an inch, and their length varies from twice to a hundred times as much. They divide by elongating to double their normal length, and subsequently pinching in, but never branch. Their movements are extremely various. He says, "the systematic place of these organisms is at present purely provisional." Lister believes he has demonstrated the origin of bacteria from a fungus, a species of dematium.

From "Researches into the Life and History of the Monads," by Messrs. Dallinger and Drysdale, published in the *Monthly Microscopical Journal* for May, I make the following extracts:

Five different forms of these microscopical objects have they thoroughly studied, and they name them respectively the cercomonad, the springing monad, the uniflagellate, the biflagellate, and the calycine monad, from what will be seen is its calyx-like form. The biflagellate was the one which first arrested their attention, and for three months almost the only one observed. But at the end of this time the others described appeared simultaneously.

"The observations of Dr. Bastian, Dr. Gros, and some others, alleging the origination of one known form from parents of an entirely different nature,........ are instances which could only be accepted scientifically by tracing the whole process, step by step, repeatedly, until every stage in the process of mutation was actually discovered and described. The possibility of misinterpreta-

tion is great. Indeed, we distrust all observations founded on successive 'dips' in a quickly changing organic infusion, and in fact put no faith in observations of this sort not conducted on the plan of keeping the same drop under continuous observation during all alleged transformations. As far as our observations upon these lowly forms go, we are bound to say that not the slightest countenance is given to this doctrine of heterogenesis. On the contrary, the life-cycle of a monad is as rigidly circumscribed within definite limits as that of a mollusk or a bird. There is no indication of any unusual or more intense methods of specific mutation than those resulting from the secular processes involved in the Darwinian law, which is held to furnish the only legitimate theory of the origin of species."

In alluding to the *sameness* of organisms in all putrefactive processes, they state, if the animal matter exists in sufficient quantity, and the process be allowed to continue for months, "then an immense variety of flagellate forms arise, often wholly extinguishing almost every trace of the bacteria and their congeners. and still the putrefactive process is carried on with great vigor. Hence we are wholly disinclined to believe that the bacteria are the only, or even (in the end) the chief organic agents of putrefaction; for most certainly in the latter stages of the disintegration of dead organic matter the most active agents are a large variety of flagellate monads.

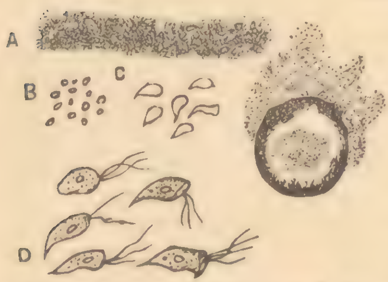
"We do not profess to decide what is the true nature of the monads we have studied; that is, to decide whether they be vegetable or animal; we, nevertheless, strongly believe in their animal nature. But if this be so, they afford another illustration of the inefficiency of the distinction between the animal and vegetable kingdom, which assumes that animals can only assimilate organic compounds, while vegetables can elaborate their protoplasm from those which are inorganic."

"The first process in the life-history of this monad is, as usual, fission, and the more carefully this process is studied, the more remarkable it appears; for we have here not a uniform homogeneous rod of sarcode, like the bacterium, which we can easily imagine by mere growth to elongate and divide by transverse fission, as it is said to do; but we have a creature of distinctly marked shape, a certain amount of structure and differentiation of

parts, of which each part appears to generate a counterpart of itself. How long *this* process may be going on we cannot exactly say, but the time taken in *visible* separation is from five to sixty minutes. In every case the division results in two individuals equal to each other in shape and apparent size; a little less in bulk than the original monad, but in every sense as perfect." The authors state that "the general method of fission was made out with the $\frac{1}{16}$, with eye-piece giving 1200 diameters; but the complete *detail* was only successfully compassed by the $\frac{1}{25}$ and $\frac{1}{50}$ of Powell and Lealand, with diameters ranging from 2500 to 5000."

"The future of these minute bodies was carefully followed with the $\frac{1}{50}$, and large numbers developed under examination; the development being distinctly traced in all its stages. First the minute and just perceptible specks (B) appeared to swell, to grow larger in all directions, but they were perfectly inactive." This continued for from two to three hours, when some of them began to have a beaked appearance (C). Their growth continued from two to three hours, when flagella were acquired (D).

FIG. 10




"The complete life-history of this monad is therefore a development from a germ or sporule of extreme minuteness, and on the attainment of maturity, multiplication by fission, constantly and for an indefinite time; but the vital power is at intervals renewed by the blending of the genetic elements, effected by the union of two, when both are in an amœboid condition, from which a still sac results, in which germs or sporules are formed, which eventually escape, and again originate the life-cycle."

In reviewing the whole series, then, it is plain that rapidity of increase and multiplication is the prominent feature in the vital phenomena of the monads. Everything subserves this end; but it also appears that the methods by which this prolificness is secured are dependent upon the recurrent blending of the genetic elements from which each species arises.

"Thus it will be seen that in no instance was the continuance

of the species maintained without the introduction of a sexual process, a blending of what are shown in the sequel to be genetic elements, and thus going further to suggest caution as to the supposition that *any* organism can be perpetuated by the mere self-division of single individuals."

The discovery of these low forms of life in the mouth is not of modern origin, as we shall see by the following from Leuwenhoek. In 1682, at the age of fifty years, he wrote respecting his teeth: "It is my custom every morning to rub my teeth with salt, and afterwards to wash my mouth, and, after eating, I always clean my large teeth with a tooth-pick, and sometimes rub them very hard with a cloth. By these means my teeth are so clean and white that few persons of my age can show so good a set; nor do my gums ever bleed, although I rub them very hard with salt; and yet I cannot keep my teeth so clean but that, upon examining them with a magnifying glass, I have observed a kind of white substance collected between them, in consistence like a mixture of flour and water. In reflecting on this substance, I thought it probable (though I could not observe any motion in it) that it might contain some living creatures. Having therefore mixed it with rain-water, which I knew was perfectly pure, I found, to my great surprise, that it contained many very small animacules, the motions of which were very pleasing to behold. The largest sort of them had the greatest and quickest motion, leaping about in the fluid like the fish called a jack; the number of these was very small. The second sort had a kind of whirling motion, and sometimes moved in the direction of a spiral and undulating; these were more in number. Of the third sort I could not well ascertain the figure, for sometimes they seemed roundish but oblong, and sometimes perfectly round. These were so small that they did not appear larger than a *speck*. The motion of these little creatures, one among another, may be imagined like that of a great number of gnats or flies sporting in the air. From the appearance of these to me, I judged that I saw some thousands of them in a portion of liquid no larger than a grain of sand, and this liquid consisted of eight parts water, and one part only of the before-mentioned substance taken from the teeth.

"With the point of a needle I took some of the same kind of substance from the teeth of two ladies who I knew were very

punctual in cleaning them every day, and therein I observed as many of these animalcules as I have just mentioned. I also saw the same in a white substance taken from the teeth of a boy about eight years old, and upon examining in like manner the same substance taken from the teeth of an old gentleman who was very careless about keeping them clean, I found an incredible number of living animalcules swimming about more rapidly than any I had before seen, and in such numbers that the water which contained them (though but a small portion of the material taken from the teeth was mixed in it) seemed to be alive."

### Paramecia.

Having now considered all the growths deemed vegetable found in the mouth, I have still one other organism to describe, as to the true place of which in nature there is no division of sentiment, it belonging undoubtedly to the animal kingdom. I allude to the paramecia, a genus of infusoria. They are only found in the oral cavity in cases of extreme uncleanliness, and though increasing rapidly in infusions adapted to their growth, they are somewhat limited in this situation, owing to the constant changing of the secretions. About fifteen varieties have been described. They have a soft, flexible body, variable in form, though usually oblong or oval, and more or less depressed. In most of them numerous rows of vibratile cillia are noticeable projecting from their integument.

The reproduction of these animalcules is effected in various ways, and not infrequently the same individual would appear to propagate by two or three different modes.

The first is by external gemmules, or buds, which sprout like minute tubercles from the surface of the body, and gradually attain the shape of the parent, soon becoming independent beings, though not attaining their full growth until after their separation.

The usual mode of propagation, however, is by spontaneous fissure, or division of the body of an adult animalcule into two or more portions, each of which is perfect in all its parts. "This fissiparous mode of reproduction is amazingly prolific. Thus, a paramecium has been observed to divide every twenty-four hours, so that in a fortnight, allowing the product of each division to multiply at the same rate, 16,384 animalcules would be evolved

from the same stock, and in four weeks the astonishing number of 268,435,456 new beings would result from a continued repetition of the process. We feel, therefore, but little surprise that with such powers of increase these minute creatures soon become infused in countless myriads through the waters adapted to their habits."

I have stated in the foregoing that the vegetable growths I have been describing belong exclusively to the fungi and algæ; but in which class they shall be placed, or whether wholly in one or the other, seems difficult to determine. In elucidating this subject, I cannot do better than quote a paragraph on "The Mode of Life" of each, from the recent work, "Text Book of Botany," by Julius Sachs.

He says, "The mode of life of algæ is determined and limited by the concurrence of two conditions besides the specific requirements of temperature, viz., water and light. The greater number of algæ are submerged aquatic plants, or when otherwise, they still require water for certain processes of development, especially for their reproduction; sometimes certain vital phenomena are caused by moistening with water after drying up the cells. Light is a universal condition of the life of algæ, inasmuch as they are all dependent upon individual assimilations in them: as elsewhere in the vegetable kingdom, this is brought about by chlorophyl, which, with the help of light, decomposes carbonic acid and evolves oxygen. Algæ are, therefore, never true parasites, although they commonly live on the surfaces of other plants." In a note he says, "This proves, however, not to be absolutely true, as Cohen has discovered a chlorophyllaceous alga which is parasitic on lemma. This at the same time affords the only means for a sharp but artificial separation between algæ and fungi. From the section of siphoneæ among the algæ containing chlorophyl to the parasitic phycomycetes among the fungi destitute of chlorophyl there occurs so gradual a transition in their morphological characters that, without the characteristic coloring, the siphoneæ and phycomycetes would have to be included in one group; but the distinction between algæ and fungi would then be at once overthrown. There exists, in fact, as may be concluded from what we have said, no definite boundary-line; but, for the sake of clearness, it is desirable to establish a conventional or artificial one;

and this is best afforded by the presence or absence of chlorophyl.

"The mode of life of fungi is in all important features determined by the fact that they are destitute of chlorophyl, and therefore do not assimilate, but are adapted to take up the assimilated carbon-compounds of other organisms. This they effect either by their mycelia absorbing from the ground the partially decomposed exuviæ of animals and plants, or they grow upon or in excrementa, or are parasites; in the latter case they may attach themselves to living plants and animals, penetrate their tissues, and thus kill them or contribute to their further decomposition. In other cases their influence on their host is less injurious; they then cause peculiar degenerations in the plants whose tissues they inhabit.

"The parasitism of fungi runs through all degrees to the greatest extremes; some of them live entirely within the tissues of plants and animals, and some are parasitic on other fungi; since, in consequence of their want of chlorophyl, they do not require light for their nourishment, they may pass through all stages of development in complete darkness, if the escape of the spores of particular processes of growth do not require light, as is the case with truffles and numerous other underground fungi. Some, however, need it for their morphological development, and do not fructify without its influence, while their mycelium, on the other hand, vegetates vigorously in the dark."

From these extracts, representing as they do the opinions of a prominent botanist, it is readily seen that no accurate line of demarkation can be drawn by which we can judge of the class to which the above-described organisms belong, and hence it is that while Robin and Küchenmeister place them with the algæ, others place them with the fungi.

I cannot close this essay without some allusion to the difficulty experienced in properly estimating the microscopical examination of much that is taken from the oral cavity, and how readily an observer may be deceived, providing he is not familiar with the appearance of foreign substances which, from locality and surroundings, are constantly liable to find a lodgment therein. To illustrate, I will enumerate what was found in a mass of material—certainly not greater in bulk than the one-fourth of a grain of wheat—taken from the mouth of a hospital patient. With this debris was mixed distilled water, in order to facilitate its exam-

ination. When placed in position, the lens revealed leptothrix fibres, both long and short, and varying in thickness as well as in length; bacteria, vibrios, and monads not a few; paramecia not so many, but yet in numbers sufficient to make their presence undoubted; pus-corpuscles in abundance, from exudations from the gum around the necks of the teeth; cryptococcus cerevisiæ from fermentations of food; stellate hairs of the ivy-leaf from a vine near the window of his room had also found a lodgment; fibres of wool from the blanket, with their cortical cells giving them their peculiar barbed appearance; fibres of cotton from the pillows and sheets, with their flat, band-like appearance and thickened borders; while the linen kerchief, in its comfort to the owner, had also given its peculiarly rounded woody fiber, with tapering ends and pits in the walls; while the epithelium scales which had served their purpose were not a few; and last, but not least, were the granules of starch from a repast not long in advance of us.

Such were the contents of a speck of material not probably the $\frac{1}{500}$ part of what remained in the mouth; and to examine it understandingly, recognizing its heterogeneity, and placing each item of this differentiated material where it belonged, was to the inexperienced microscopist a work of hours.

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*Note.*—From my examination of the the leptomitus and leptothrix, as well as of other filaments found in the mouth, I am inclined to believe their difference is more in degree than in kind; but this is a presumption that could only be sustained by repeated careful and prolonged investigations.

Another semi-conviction I wish to express is, that the accretion and consolidation of tartar is somewhat due to the profuse growth of leptothrix, by its consumption of the animal and vegetable portions of the deposit, leaving the mineral residuum to adhere to the natural teeth or artificial dentures.

And a third query is in reference to the parasitic nature of many of the growths just described. The assumption that they are all true parasites may wisely be questioned, inasmuch as parasites are defined to be organisms growing upon the living parts of other organisms, from the juices of which they derive their nutriment.